# FINAL REPORT:
# USGS NETWORK OPERATIONS
# NEHRP CONTRACT

## Funding Period: 1995-1997

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## Introduction

The USGS Earthquake Hazards Program has supported the Western Great Basin Seismic Network (WGBSN) operated by the University of Nevada Reno (UNR) for several decades. This report describes accomplishments during the 1995-1997 funding period under NEHRP Grant: 1434-05-A-01298. During this time period there have been considerable changes to seismic network operations at UNR. Although still fundamentally funded to operate a number of short-period analog instruments in the western Great Basin (Figure 1), by the end of 1997 about 30 three-component high-dynamic range REFTEK digital dataloggers were being telemetered to UNR (Figure 2). The bulk of these stations were funded and are operated under a Department of Energy (DOE) contract to monitor earthquake activity in the Yucca Mountain area in southern Nevada (Figure 2); potential site for the nation's high-level nuclear waste repository. However, due to this increased capability for acquiring high-quality digital data, and through a grant from the Keck Foundation, we were able to add 7 of these high quality digital instruments to the Nevada network, significantly improving the monitoring capability in the metropolitian areas of Reno-Carson City and Las Vegas. One of these instruments is installed in the Long Valley Caldera area in order to monitor for potential volcanic earthquakes.

Microwave access has been extended to Las Vegas and to central Nevada and much needed upgrades to existing mircowave facilities at Long Valley, CA, have been completed. Modifications of telemetry systems in Long Valley and to Las Vegas were necessary to accept the full-duplex communications required by the REFTEK digital instruments. Also, we have provided microwave access for and NSF project under the direction of Brian Werneke, Caltech, for real-time GPS monitoring in northern Nevada and the northeastern Sierra. Wally Nicks, Electronics Design Engineer carried out the technical aspects of establishing communications to these stations, and the system was fully operational in 1997. Remote queries can be made directly to the field GPS units through the microwave system via computer link to UNR.

During the 1995-1997 time period we established routine monthly submittals of all located earthquakes to the Berkeley Data Center in support of CNSS objects. Also we have significantly improved the near-real time reporting of earthquake information and general earthquake hazard information for Western Nevada region through the UNR Seismology Lab Web page (http://quake.seismo.unr.edu).

From 1995 through 1997 there were no significant earthquake sequences to report. The last moderate sized earthquake in the Nevada region was the 1994 Double Spring Flat earthquake that occurred about 50 km south of the Reno area. During the reporting period we located 7721 earthquakes using the analog network (this does not include events located for the DOE Yucca Mountain Project). Of these 129 were M 3.5 and greater with 44 M 4.0 and greater (Table 1, at end of report). The lower event count is due to the fact that we no longer locate earthquakes in the Mammoth Lakes area, amount to a duplication of USGS Menlo Park efforts, although we continue to maintain those stations.

We have installed a PC and digitizer and multiplexing boards to accept the analog network data into an Earthworm or Earthworm equivalent processing system. Over the funding period we worked with the University of Alaska Fairbanks (UAF) to help establish an Earthworm/Iceworm (Iceworm is the UAF vintage of Earthworm with Datascope extensions) that accepted digital data from a variety of instrumentation. We participated in the software development of these systems and ran several tests of the system at UNR with the UNR analog and REFTEK digital networks.

**Southern Great Basin Analog Seismic Network**

The University of Nevada Reno is funded by the Department of Energy to monitor earthquakes in southwestern Nevada for the Yucca Mountain Project (Figure 2). In October 1995, funding from the DOE to operate the southern Great Basin analog network, in operation since 1978, was terminated. Since that time the primary network, and the only stations funded by the DOE for Yucca Mountain monitoring, has been an array of 25 REFTEK three-component digital instruments located within 50 km of the Yucca Mountain site. This digital network is significantly reduced in coverage area from the older analog net; from about 120,000 km$^2$ to roughly 8,000 km$^2$, although the detection threshold and completeness levels vary significantly between networks. Since

1995 UNR has maintained some of the analog stations from the older network with primary focus on coverage around the Las Vegas area and along the major fault zones of the Eastern California Shear Zone. As of the time of this report, it appears that many of these analog stations will be removed from the field. This will particularly impact coverage in southeastern Nevada; site of the 1966 M 6.0 Caliente earthquake and the active Pahranagat Shear Zone. Although many of these stations have remained unfunded since October 1995, we have continued to use phase arrivals from these stations to contribute to the earthquake catalog that is submitted to the Berkeley Data Center. Supplemental USGS funding during the 1995-1997 time frame has contributed to support for operations of southern Nevada analog stations. In the near future, though, there will be significant changes to the detection threshold, completeness level and location quality for earthquakes in the central and eastern Nevada regions. It is not in the interest of CNSS objectives to remove stations from the field, but there has been little interest from funding agencies to support the operation of these stations.

**Seismicity in the Western Great Basin 1995-1997**

Earthquake activity in the Western Great Basin of eastern California and western Nevada accounts for some portion of the 10 mm/yr of regional strain resulting from the northwestward motion of the Sierra Nevada block (Dokka and Travis, 1990). This is about 20% of the western North America strain budget. The seismicity is concentrated along the Eastern California shear zone, the Sierra Nevada Great Basin boundary zone and through the central Nevada Seismic Belt. The strain rates of the major through going strike slip faults of the eastern California shear zone (Fish Lake Valley, Owens Valley, Furnace Creek Death Valley fault zones) have been estimated to range between 4 and 10 mm/year (Dixon et al., 1995). Accounting for the strain budget through the central Walker Lane is more problematical than it is to the south. Continued monitoring, in particular with 3-component instruments, will help resolve some of these scientific issues. The earthquake history of the Reno-Carson City urban area includes a number of potentially damaging earthquakes that have occurred within the past 150 years. Several

M > 6.5 earthquakes fortunately occurred during a period of time when few people lived in the region (dePolo et al., 1997).

The seismicity of the 1995-1997 time period follows the general patterns of previous reporting periods. Since we are no longer locating earthquakes in Long Valley Caldera there are fewer earthquakes to report. Figures 3 and 4 show the earthquakes located during the reporting period and several significant areas of activity are labeled in Figure 3. Table 1 at the end of the report lists all events greater than M 3.5 and are those events shown in Figure 4.

The following discussion refers to numbered locations labeled in Figure 1. Labeled #1 is the 1995 M 4.5 Bordertown Earthquake. This event was felt widely through the Reno-Sparks metropolitan area and was within 1 focal depth of the UNR Seismological Laboratory. Several portable instruments were deployed for this sequence and a publication was generated that evaluated the sequence and the earthquake source parameters (Ichinone et al., 1997). This was a normal faulting event on a steeply dipping fault plane. Labeled #2 is the aftershock zone of the 1994 M 6.0 Double Spring Flat sequence. Post event deployment of portable instrumentation also resulted in a publication on the seismotectonics of this area (Ichinose et al., 1998). The sequence extended well into 1995 and also progressed southward in an unusual pattern for western Great Basin earthquakes. Labeled #3 is the eastern portion of the Mammoth Lakes sequence area that is out of the Long Valley Caldera and includes continuing aftershocks of the 1986 M 6.3 Chalfant earthquake sequence. Labeled #4 is the 1997 M 5.1 Northern Fish Lake Valley earthquake. This was strike-slip faulting event at the northern end of the Fish Lake Valley fault zone. Is appears to have ruptured on a northeast striking fault plane in contrast to the northwest striking Fish Lake Valley fault. Label #5 is a late M 5.0 aftershock of the 1993 M 6.0 Eureka Valley earthquake. This sequence is also obvious in Figure 1 and has continued into the 1995-1997 time period. Labeled #6 is the Ridgecrest sequence and due to a lack of station coverage location accuracy is poor for the UNR network for events in this region. Labeled #7 is the region of the southern Nevada Test Site and the location of the 1992 M 5.6 Little Skull Mountain earthquake. Because of the high station density in the southern Nevada Test Site (NTS) there is a bias to a much lower detection threshold and an artifical appearance of high seismicity rates in the NTS area. Although this has been historically the case, the Little Skull Mountain sequence and other M 3.5 events have legitimately increased the seismicity rate for the southern Nevada Test Site for the reporting period. Labeled #8 shows the activity in the Parhanagat Shear Zone. Stations in this region are planned for removal in 1998-1999 (see discussion above concerning the Southern Great Basin analog network).

**Seismic Network Maintenance**

The vast majority of funds from the USGS grant are applied to routine maintenance of remote seismograph stations and communications systems. In 1996 we installed monitors at the microwave nodes to transmit several aspects of station performance; in this way we can often respond to problem components or potential power problems before components completely fail. In 1997, to resolve recurring problems with the microwave link in the Mammoth Lakes area, we upgraded that node. This assures better performance and more reliability through the winter months when failures are more likely, power requirements are the greatest, and access is difficult. This upgrade also included the installation of full-duplex microwave communications to UNR that was necessary for the REFTEK instrument which was installed in late 1997.

UNR has also installed 7 REFTEK digital seismographs and the communications necessary to bring the broadband data to the Reno campus. These are stations outside of the Yucca Mountain network. This process involves site selection and permitting through the applicable land management organization and finally construction. Sites are remotely powered and include a mast for send and receive antennas, battery box and instrument box. All electronics are mounted on the antenna mast. Sensors are either 30 second Guralp CMG-40T's or 1 second Geotech S-13s, and are placed in buried vaults. Additional stations are planned.

**Nevada Seismic Safety Council**

In 1995 the State of Nevada sanctioned the establishment of the Nevada Earthquake Safety Council (NESC) to address earthquake hazard issues in the State. An important issue for the NESC is the area of emergency response and notification regarding important earthquake in Nevada. Through this forum the Seismological Laboratory is directly in communication with State and Federal FEMA officials and we can address the issues of providing earthquake information to those agencies and groups that need it most. Also of concern to the NESC are efforts that the USGS has made to characterize and categorize the earthquake hazard in Nevada. Some of recommendations of the NESC will undoubtedly impact engineering design standards for the State. Some of the fundamental input for these decisions is derived from the earthquake catalog developed through the USGS Network contract.

**REFTEK Three-Component Digital Stations**

During the period of this contract UNR has been fortunate to secure a grant from the Keck Foundation for the purchase of about fifteen REFTEK 72-A08 digital seismographs (Figure 2). At this time nine of these instrument are in operation outside of the Yucca Mountain contract, and six were operating by the end of 1997. This grant does not provide for operational support so maintenance and data analysis for these stations is performed under the USGS grant. There are four in northern Nevada, one in the Yerington area, one outside of Walker, CA, one in and one in the Mammoth Lakes area. Because the software to bring the data from these stations to the local computer systems had previously been developed under the Yucca Mountain contract, it is in principal very simple to add more stations. There is currently sufficient microwave bandwidth and in-house hardware to add an additional 20 to 30 digital stations to the network. The stations operate in two recording modes, which are fully programmable from the Reno office; these are a 100 sps triggered data stream and a 20 sps continuous data stream. Triggered records are archived in 150 second length SEGY format files. Several hundred triggers are reviewed each day and all earthquake signals are archived. Daily calibrations are performed on at all stations and archived with both the triggered and continuous streams in raw PASSCAL REFTEK format.

## Data Management

The fundamental system for our analog network processing through the 1995-1997 time period remained the USGS VAX-VMS CUSP processing system. This system is aging and we have discontinued the costly yearly hardware support. The system has been very reilable over the years and continues to perform, although there is serious concern about its longevity. The CUSP system operates on a network trigger basis. All earthquakes are hand picked and located by an analyst. The event data is archived in MEM and GRM format on DAT tape. We have been participating in the CNSS requirement for maintaining a national catalog of earthquake locations and submit hypocentral information to the Berkeley Data Center on a monthly basis.

In the spring of 1997, in a cooperative effort with the University of Alaska Fairbanks (UAF), the Earthworm/Iceworm system was installed in Reno to accept data from the REFTEK digital instruments. We worked closely with UAF in redesigning the picker modules in Earthworm prior to this installation to accept packetized digital data. These protocols have been adopted by UAF in their ICEWORM 1.0 distribution. During the installation we also established the links to Golden, Colorado, to transmit UNRSL digital data and receive selected NSN stations. These data were then organized in the Datascope database. This was a feasibility study to test whether UAF processing systems could easily be ported to other institutions operating in a UNIX environment.

The data from the REFTEK network is not integrated into the analog data stream. Only for events of special interest are the arrival times merged from the two data sets. We have not pursued the integration of the data in the anticipation of finding a UNIX based solution for the analog stream. This solution may be the EARTHWORM processing system developed by the USGS or possibly the ANTELOPE system developed commercially by Boulder Real Time Systems and currently distributed by Kinemetrics Corporation.

In 1997 a PC and National Instruments digitizing and multiplexer boards were purchase with USGS funds to establish analog network Earthworm processing in Reno. This system was installed and operational in 1997. We completed the design and installation of isolation amplifier to reduce noise and crosstalk. This design was shared with UAF and University of Utah. The complete Earthworm/Iceworm system did not become operational in 1997 because of technical issues with regard to REFTEK data formats. UNR would like to evolve away from the VAX-VMS CUSP system, but we require a solution that will allow us to integrate both analog and REFTEK digital data. As can be seen from Figures 1 and 2, a substantial portion of the Nevada Network is now comprised of REFTEK instruments with more planned in the future.

**Dissemination of Real-Time and Near Real-Time Information**

Real-time waveform data exchange will be maintained with a number of institutions for about 27 analog stations. Data from these stations are transmitted to Menlo Park (stations from the Long Valley area), California Division of Water Resources (stations in northern California) and NEIC (selected stations for optimum coverage through the western Basin and Range). We provide a microwave link from Long Valley to Reno for Menlo Park for most USGS network stations in the Mammoth Lakes area. The phase data from several stations in the Eastern California shear zone are shared with the Southern California network. These stations, as well as a number of stations to the north along the Fish Lake Valley and Owens Valley fault zones, will not be removed from the southern Great Basin analog network. We have tested the data link with NSN Golden, but did not pursue data transmission for UNR northern Nevada digital stations because of recurring problems with the Guralp CMG-40 sensors. These instruments have only recently been replaced by Guralp and will be swapped with the current field instruments in the near future. Real-time earthquake locations are displayed on the UNR Seismolab Web Site, and this information is directly available to the public. These are near real-time locations generated through the CUSP processing system. There is no real-time earthquake information provided through the REFTEK digital network.

Data collected at the UNR REFTEK station in Mammoth Lakes has been provided to Sue Hough, USGS Pasedena, in support of a PASSCAL funded project that collected data from a number of portable instrument following increased activity in the Long Valley Caldera in 1997.

## Web Site Development and Dissemination of Earthquake Information

UNR has aggressively pursued the development of an Internet Web Site for the dissemination of earthquake information. Dr. John Louie has spearheaded an effort that has resulted in a very popular site at UNR, providing information about Nevada earthquakes and links to other earthquake related sites and information sources. We have averaged about 60,000 hits per week during some time periods which we believe translates to at least 2,000 visitors over any 7 day period. The NBE, Nevada Broadcast of Earthquakes, is now available on the Web with local and state maps. Unfortunately, as much as 30% of the earthquake locations reported in near-real time are incorrect; this is because of the number of telemetry noise-triggers in the analog system.

A popular site on our Web page is the Heliocorder-Camera that displays a digital image of the current long-period heliocorder record. Hand-picked and located events are also displayed in map view from the *Recent Earthquakes* listing. Also, we accumulate earthquake felt reports from all over the world with an electronic form available at our the Web site, and this information is forwarded to the USGS in Menlo Park. Other popular items on the UNR Web page are the Records of the Week, which are a teleseism, regional and local event recorded on the UNR network. The Web Site also links a catalog search routine to query the UNR historical earthquake catalog and produce maps of seismic activity. There is also information as to the contacts for acquiring all available earthquake information (phase data and waveform data) from the UNR archive; at present we do not have an automated system for data delivery.

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Table 1. $M > 3.5$ Earthquakes Located 1994-1997

| *Origin Time* | | | *Latitude* | *Longitude* | *Z* | *M* | | *gap* | | *rms* | *Q* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 950101 | 1459 | 43.41 | 36- 2.82 | 114-49.60 | 4.42 | 3.67 | 31 | 169 | 15 | 0.03 | ac |
| 950106 | 0011 | 61.74 | 38-46.73 | 119-39.44 | 0.00 | 4.12 | 19 | 103 | 13 | 0.15 | ac |
| 950212 | 1753 | 51.03 | 37-56.90 | 118-28.69 | 2.10 | 3.62 | 49 | 44 | 8 | 0.12 | ab |
| 950218 | 2016 | 70.65 | 38-47.11 | 119-39.68 | 5.96 | 3.98 | 43 | 88 | 12 | 0.10 | ac |
| 950319 | 1631 | 70.44 | 37-31.73 | 118-25.75 | 9.48 | 3.69 | 43 | 48 | 10 | 0.14 | ab |
| 950422 | 1431 | 31.64 | 38-47.16 | 119-41.08 | 2.76 | 4.39 | 35 | 141 | 13 | 0.19 | bc |
| 950508 | 1819 | 46.78 | 38-37.26 | 118-26.89 | 6.86 | 3.65 | 35 | 48 | 6 | 0.12 | aa |
| 950527 | 0549 | 42.44 | 38-48.82 | 119-38.56 | 5.46 | 3.78 | 24 | 95 | 9 | 0.15 | ab |
| 950603 | 1721 | 40.96 | 37-13.00 | 114-44.61 | 8.68 | 3.94 | 50 | 179 | 34 | 0.10 | ac |
| 950618 | 2223 | 23.00 | 39-51.33 | 120-44.97 | 3.53 | 3.85 | 20 | 159 | 48 | 0.12 | ac |
| 950705 | 1235 | 81.53 | 38-49.03 | 119-37.43 | 8.65 | 3.69 | 24 | 90 | 8 | 0.08 | aa |
| 950731 | 1234 | 47.05 | 37- 5.77 | 116-24.57 | 16.35 | 4.18 | 54 | 26 | 7 | 0.11 | aa |
| 950812 | 2350 | 1.44 | 41-13.55 | 116-18.47 | 8.82 | 3.80 | 10 | 323 | ** | 0.14 | dd |
| 950907 | 2114 | 83.44 | 36-39.88 | 116-12.69 | 0.93 | 3.50 | 62 | 42 | 5 | 0.11 | ab |
| 950922 | 1447 | 21.56 | 38-43.38 | 118-34.65 | 7.29 | 4.44 | 44 | 64 | 11 | 0.11 | ab |
| 951016 | 2106 | 38.47 | 38-49.19 | 119-37.53 | 10.07 | 3.75 | 39 | 81 | 8 | 0.10 | aa |
| 951115 | 2033 | 59.21 | 39-38.65 | 120- 0.40 | 11.52 | 4.61 | 48 | 60 | 9 | 0.15 | aa |
| 951116 | 1459 | 24.68 | 39-38.83 | 120- 0.77 | 11.37 | 3.81 | 29 | 61 | 9 | 0.11 | aa |
| 951119 | 0011 | 48.76 | 37- 8.06 | 115-45.33 | 10.59 | 3.57 | 40 | 57 | 22 | 0.12 | ac |
| 951123 | 0839 | 33.12 | 37- 7.84 | 115-45.29 | 10.73 | 3.58 | 36 | 57 | 22 | 0.19 | bc |
| 951130 | 0938 | 49.38 | 37- 8.42 | 115-45.83 | 13.80 | 3.66 | 28 | 83 | 21 | 0.18 | bb |
| 951130 | 1218 | 64.38 | 36-28.78 | 115-24.83 | 13.12 | 3.91 | 41 | 84 | 22 | 0.07 | ab |
| 951222 | 0900 | 33.83 | 38-44.05 | 119-35.43 | 6.82 | 4.67 | 48 | 70 | 17 | 0.09 | ac |
| 951223 | 0538 | 116.2 | 38-44.87 | 119-35.32 | 6.90 | 4.64 | 36 | 72 | 16 | 0.13 | ac |
| 951223 | 0538 | 132.2 | 38-44.87 | 119-35.32 | 6.90 | 4.72 | | | | | |
| 951228 | 1827 | 60.69 | 38-43.63 | 119-36.74 | 8.62 | 4.91 | 91 | 72 | 18 | 0.08 | ac |
| 960102 | 0625 | 102.2 | 38-44.71 | 119-35.53 | 6.74 | 4.03 | 32 | 72 | 16 | 0.08 | ac |
| 960107 | 1032 | 46.41 | 36-27.74 | 117-36.11 | 5.64 | 3.88 | 29 | 188 | 35 | 0.11 | ad |
| 960202 | 0040 | 31.13 | 39-57.24 | 120-51.84 | 6.31 | 3.68 | 16 | 199 | 51 | 0.10 | ad |
| 960309 | 0118 | 66.30 | 38-43.21 | 119-36.34 | 5.08 | 4.21 | 36 | 70 | 19 | 0.10 | ac |
| 960602 | 0659 | 55.90 | 39-40.42 | 115- 7.96 | 7.09 | 4.39 | 21 | 236 | 99 | 0.32 | cd |
| 960627 | 0548 | 62.03 | 38-37.89 | 119-28.22 | 12.80 | 4.27 | 24 | 70 | 29 | 0.08 | ac |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 960726 | 1252 | 38.69 | 36-43.72 | 116-17.60 | 9.81 | 3.63 | 34 | 35 | 2 | 0.10 | aa |
| 960816 | 1041 | 19.88 | 39-21.76 | 116-35.74 | 8.75 | 3.61 | 29 | 165 | 99 | 0.12 | ad |
| 960831 | 2258 | 42.03 | 36-42.71 | 116-18.44 | 10.31 | 3.57 | 29 | 52 | 2 | 0.09 | aa |
| 960905 | 0816 | 55.80 | 36-43.10 | 116-18.27 | 9.63 | 3.55 | 26 | 32 | 1 | 0.11 | aa |
| 960905 | 1623 | 81.36 | 36-20.75 | 117-32.23 | 17.73 | 3.63 | 11 | 196 | 39 | 0.19 | cd |
| 961008 | 1355 | 407.8 | 37-56.52 | 118- 8.23 | 5.64 | 4.02 | 58 | 102 | 10 | 0.13 | ab |
| 961017 | 1546 | 95.41 | 37-28.54 | 116-22.38 | 13.50 | 3.81 | 24 | 52 | 29 | 0.10 | ac |
| 961017 | 1944 | 25.47 | 37-28.86 | 116-22.24 | 14.93 | 3.93 | 28 | 52 | 28 | 0.14 | ab |
| 961019 | 2119 | 30.99 | 37-28.89 | 116-22.41 | 15.43 | 3.93 | 25 | 54 | 28 | 0.12 | ab |
| 961022 | 0414 | 72.33 | 36-10.19 | 115- 9.98 | 6.52 | 3.71 | 12 | 266 | 37 | 0.00 | ad |
| 961105 | 1504 | 81.57 | 37-29.20 | 116-22.69 | 16.14 | 3.54 | 34 | 52 | 28 | 0.13 | ab |
| 961127 | 2017 | 21.39 | 36- 1.85 | 117-49.59 | 0.00 | 4.94 | 27 | 245 | 76 | 0.15 | cd |
| 961127 | 2228 | 65.58 | 36- 2.66 | 117-44.37 | 2.83 | 3.67 | 17 | 283 | 69 | 0.10 | bd |
| 961128 | 2205 | 55.73 | 36- 3.91 | 117-44.03 | 0.00 | 3.67 | 28 | 238 | 67 | 0.04 | ad |
| 961130 | 2210 | 73.42 | 36- 4.29 | 117-43.92 | 0.00 | 3.52 | 28 | 242 | 67 | 0.13 | bd |
| 961202 | 2332 | 73.03 | 40- 1.77 | 119-37.35 | 13.11 | 3.79 | 15 | 95 | 19 | 0.05 | ab |
| 961212 | 1835 | 49.33 | 38-40.31 | 119-31.73 | 5.13 | 4.45 | 40 | 86 | 25 | 0.08 | ac |
| 961213 | 1652 | 77.28 | 38-39.96 | 119-30.77 | 4.19 | 4.22 | 26 | 77 | 26 | 0.11 | ac |
| 961213 | 2315 | 24.74 | 38-40.43 | 119-30.61 | 3.94 | 3.69 | 26 | 77 | 25 | 0.14 | ac |
| 970104 | 1458 | 35.83 | 36- 8.81 | 117-39.62 | 1.66 | 4.07 | 24 | 252 | 57 | 0.10 | ad |
| 970112 | 0001 | 47.31 | 36- 2.76 | 117-42.32 | 0.00 | 3.50 | 20 | 238 | 66 | 0.16 | bd |
| 970117 | 1854 | 72.28 | 37-10.50 | 115-56.97 | 16.73 | 3.90 | 34 | 45 | 23 | 0.16 | bb |
| 970215 | 0421 | 69.37 | 36- 5.10 | 117-40.03 | 1.58 | 3.81 | 27 | 229 | 61 | 0.16 | bd |
| 970215 | 0813 | 45.85 | 36- 3.56 | 117-45.78 | 0.00 | 3.88 | 17 | 244 | 70 | 0.08 | bd |
| 970414 | 1120 | 53.89 | 38- 4.27 | 118-43.97 | 8.37 | 4.17 | 40 | 46 | 3 | 0.08 | aa |
| 970426 | 0149 | 35.44 | 37-10.28 | 115-58.01 | 9.52 | 4.34 | 28 | 92 | 5 | 0.15 | ab |
| 970516 | 0123 | 21.65 | 40-39.12 | 114-51.55 | 17.26 | 4.13 | 18 | 274 | 99 | 0.18 | dd |
| 970610 | 0102 | 38.99 | 35-56.93 | 117-44.94 | 6.65 | 3.65 | 21 | 287 | 76 | 0.13 | bd |
| 970614 | 1947 | 79.38 | 36-36.83 | 115-49.40 | 4.57 | 4.27 | 23 | 107 | 8 | 0.13 | ab |
| 970821 | 1535 | 33.69 | 38-35.73 | 118-30.31 | 11.27 | 4.19 | 55 | 42 | 3 | 0.11 | aa |
| 970821 | 1609 | 144.7 | 38-35.64 | 118-30.51 | 11.14 | 4.54 | 63 | 42 | 3 | 0.12 | aa |
| 970821 | 1636 | 47.73 | 38-35.60 | 118-29.92 | 9.97 | 4.55 | 56 | 43 | 4 | 0.11 | aa |
| 970829 | 1548 | 8.52 | 41-54.59 | 119-46.53 | 0.47 | 3.59 | 12 | 299 | 99 | 0.19 | bd |
| 970912 | 1336 | 54.65 | 36-51.12 | 116-15.60 | 13.44 | 4.15 | 37 | 38 | 8 | 0.22 | ba |
| 970919 | 1303 | 64.85 | 38-21.65 | 115-24.14 | 13.50 | 3.65 | 10 | 262 | 99 | 0.14 | dd |
| 971006 | 1829 | 39.44 | 35-49.23 | 116-38.63 | 11.25 | 3.50 | 18 | 255 | 25 | 0.06 | ad |
| 971023 | 0529 | 75.30 | 37-57.32 | 118-41.33 | 6.37 | 3.58 | 49 | 51 | 2 | 0.14 | aa |
| 971029 | 1000 | 26.26 | 37-34.56 | 118-25.26 | 10.55 | 3.98 | 36 | 44 | 7 | 0.10 | aa |
| 971030 | 0336 | 41.75 | 37-50.90 | 118-12.83 | 6.97 | 3.70 | 38 | 90 | 14 | 0.13 | ac |
| 971102 | 0834 | 22.40 | 37-50.93 | 118-12.61 | 6.05 | 4.33 | 49 | 63 | 14 | 0.13 | ac |
| 971102 | 0851 | 53.93 | 37-50.78 | 118-12.91 | 6.38 | 5.30 | 75 | 56 | 14 | 0.11 | ac |
| 971102 | 0914 | 54.35 | 37-50.76 | 118-12.62 | 6.45 | 3.53 | 59 | 69 | 14 | 0.11 | ac |
| 971102 | 1502 | 63.83 | 37-50.60 | 118-12.18 | 6.50 | 4.49 | 75 | 62 | 15 | 0.10 | ac |
| 971102 | 1622 | 52.56 | 37-52.33 | 118-13.15 | 6.35 | 4.40 | 64 | 64 | 11 | 0.10 | ab |
| 971102 | 1753 | 65.09 | 37-51.17 | 118-11.54 | 4.90 | 3.76 | 41 | 69 | 14 | 0.12 | ac |
| 971105 | 1749 | 29.20 | 39-57.29 | 120-48.99 | 6.58 | 4.48 | 27 | 255 | 48 | 0.05 | ad |
| 971105 | 2259 | 67.54 | 37-14.80 | 117-50.70 | 10.20 | 4.24 | 77 | 110 | 17 | 0.14 | ab |
| 971106 | 1001 | 57.51 | 37-50.95 | 118-12.23 | 6.03 | 3.50 | 39 | 69 | 14 | 0.11 | ac |
| 971110 | 0135 | 44.67 | 37-50.85 | 118-12.79 | 5.71 | 3.97 | 57 | 69 | 14 | 0.11 | ac |
| 971110 | 1636 | 58.66 | 37-51.13 | 118-12.92 | 5.77 | 3.62 | 35 | 91 | 13 | 0.10 | ac |
| 971115 | 0600 | 20.33 | 37-15.52 | 117-51.55 | 6.10 | 5.00 | 74 | 111 | 15 | 0.11 | ac |
| 971115 | 0642 | 28.89 | 37-16.28 | 117-52.43 | 5.40 | 3.78 | 50 | 109 | 20 | 0.08 | ac |
| 971219 | 0706 | 60.75 | 36-29.15 | 117-38.51 | 1.74 | 3.51 | 16 | 218 | 37 | 0.15 | bd |

# Analog Network Stations

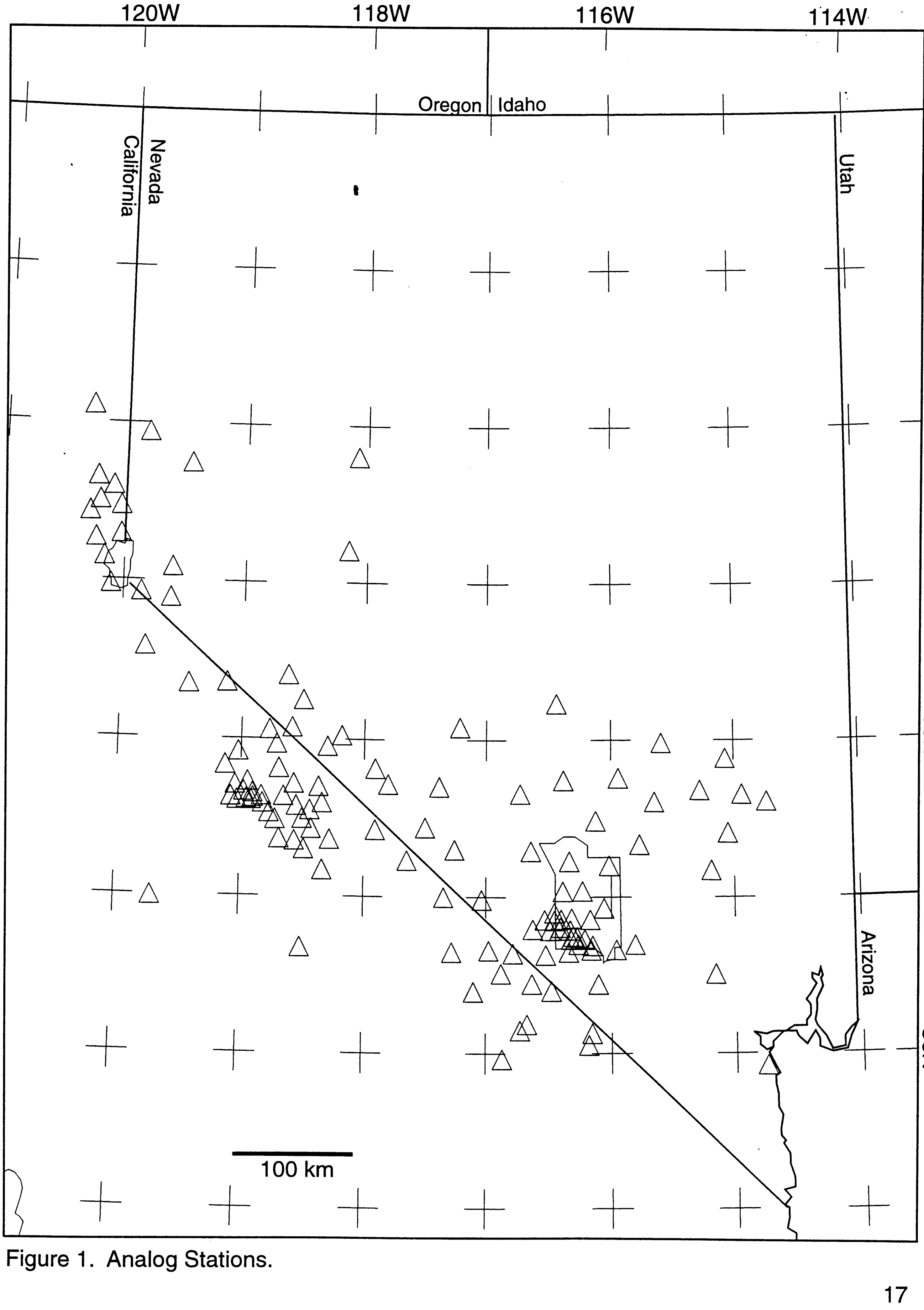


Figure 1. Analog Stations.

# REFTEK Digital Stations

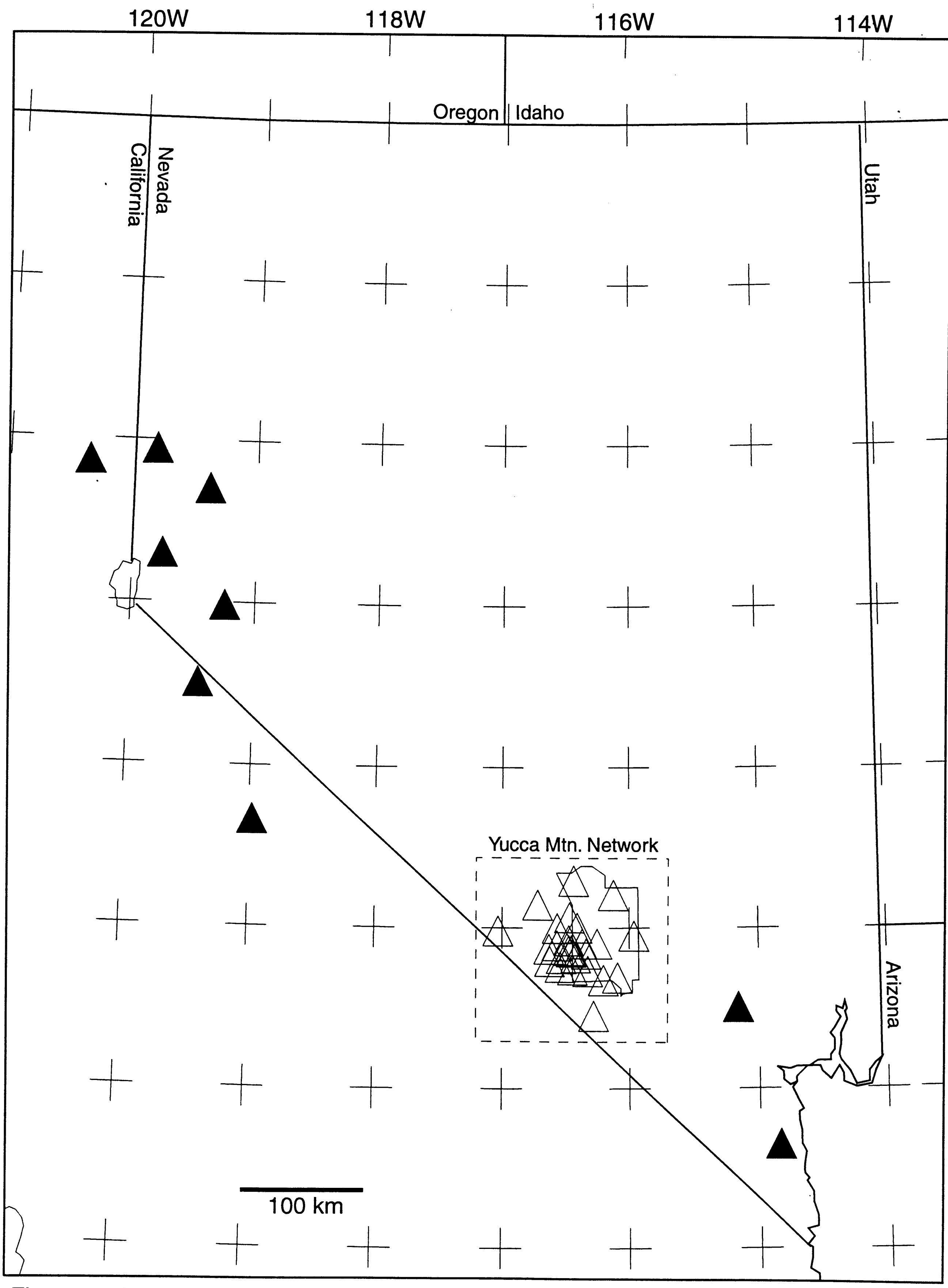


Figure 2. Digital Staitons.

▲ Funded by the Keck Foundation

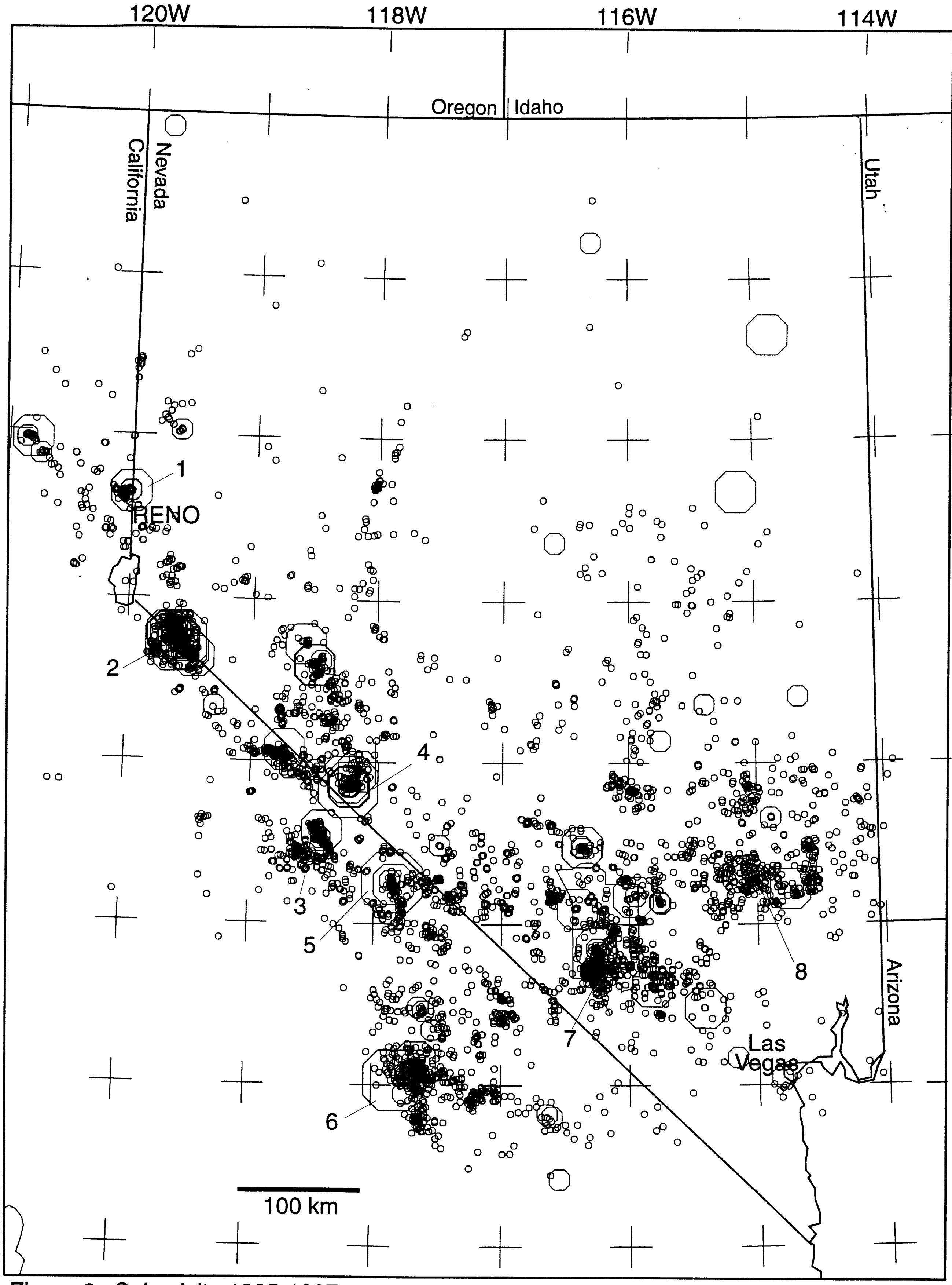


Figure 3. Seismicity 1995-1997.

1) 1995 Bordertown Earthquake
2) 1994 Double Spring Flat Sequence
3) Mammoth and 1986 Chalfant Sequences
4) 1997 M 5.1 Fish Lake Valley Earthquake
5) 1993 Eureka Valley Sequence
6) 1997 Ridgecrest Sequence
7) 1992 Little Skull Mt. Sequence
8) Pahanagat Shear Zone

Magnitude

< 3.5 3.5-3.9 4.0-4.9 5.0 +>

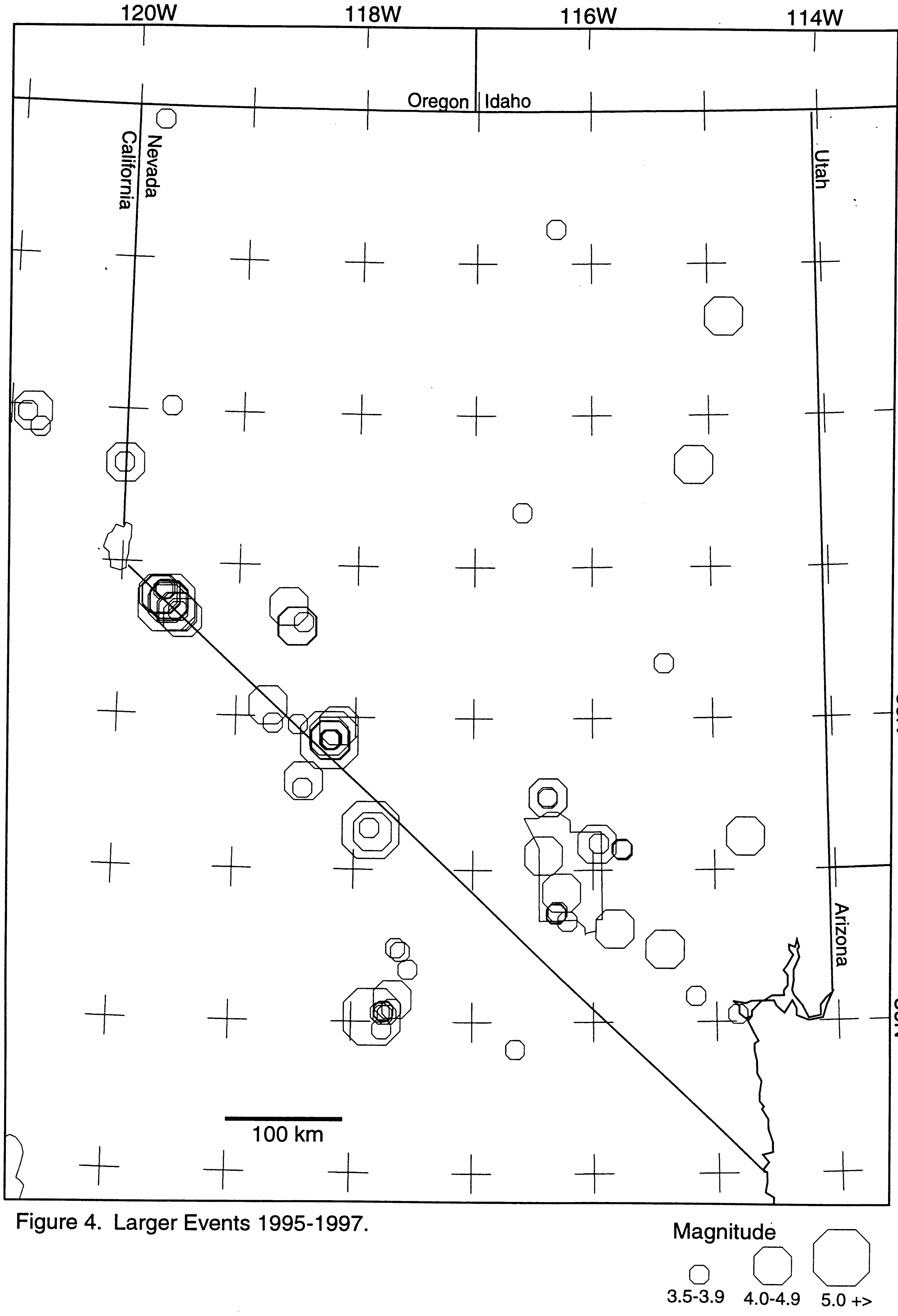


Figure 4. Larger Events 1995-1997.